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INDUSTRIAL UTILIZATION OF CULL AND SURPLUS POTATOES

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Efficient utilization of cull and surplus potatoes presents many difficulties. Culls, which constitute from 5 to 15 per cent of the annual crop, create a utilization problem each year, and this is magnified by the occasional surplus crop. The problem of surplus potatoes was made unusually conspicuous by the record crop in 1946. Since the consumption of potatoes as a food does not vary appreciably with fluctuations in their availability and price, outlets for surplus potatoes must be sought through industrial utilization.

The yield of potatoes increased from an average of 126 bushels per acre in the 1935-1944 period to 155 in 1945 and an all-time record of 184 in 1946. The 1946 crop was grown on the smallest acreage planted since 1892, and the 1947 crop was planted on a still smaller acreage (Table 1).

Several factors are responsible for the huge potato surpluses of 1943 and 1946. During the war, it was necessary to produce an enormous amount of food, requiring maximum agricultural efficiency. There was a switch from low-yielding to high-yielding areas. Chemical fertilizers were applied more commonly and in greater amounts than ever before. Improved insecticides were introduced; widespread use of DDT for the first time is generally believed to have been instrumental in developing the record potato crop in 1946. Finally, the ideal weather of the 1946 season played an important rôle.

TABLE 1 *Acreage, yield, and production of potatoes in the United States from 1935-1947**

Year	Acreage Harvested	Yield Acre	Production
	1000 acres	Bushels	1000 Bushels
1935	3,469	109.2	378,895
1936	2,969	109.4	323,955
1937	3,055	123.2	376,448
1938	2,870	124.0	355,848
1939	2,813	121.7	342,372
1940	2,832	133.1	376,920
1941	2,693	132.1	355,697
1942	2,671	138.1	368,899
1943	3,239	141.7	458,887
1944	2,786	137.6	383,424
1945	2,700	155.1	418,765
1946	2,580	184.5	475,969
1947	2,190	168.1	379,886

*Source: U. S. Department of Agriculture, Bureau of Agricultural Economics.

Industrial utilization of surplus potatoes is difficult because of the uncertainty of supply. Moreover potatoes are perishable, and must be processed within a limited time after harvesting. Since potatoes contain about 80 per cent water, transportation is expensive, and handling costs are high. Other principal crops which sometimes are harvested in surplus, for example, corn, wheat, cotton, and tobacco, can be put into storage at ordinary temperature without processing, and thus can be saved to offset a lower yield of a following year. But potatoes that are not kept in cold storage or preserved by some other treatment will sprout, which destroys not only their appearance as a food product but also much of their carbohydrate constituents.

Stated broadly, the problem of utilizing cull and surplus potatoes can be solved or alleviated by (a) developing new non-food outlets, preferably profitable, for fresh potatoes, (b) by improved methods for converting potatoes into stable forms to permit storage for utilization later as food, feed or industrial raw materials, and (c) developing efficient and economical methods of storing fresh potatoes. Because of the many disadvantages involved in dumping potatoes, probably it is preferable in some instances to divert surplus potatoes into industrial channels without profit or even at a slight monetary loss.

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Current Outlets for Cull and Surplus Potatoes

Several well-established outlets now exist for diversion of cull and surplus potatoes from the regular table stock market. Potatoes are used in food-processing industries, livestock feeding, starch production, alcohol production, and in smaller miscellaneous outlets. Beginning in 1937 and continuing during surplus crop years, the U. S. Department of Agriculture has operated diversion programs under which industrial users of surplus potatoes obtained them at low cost.

Starch Production.—Utilization of potatoes for starch production is perhaps the oldest industrial use. Early in the history of the potato starch industry, potatoes of high starch content were grown specifically for this purpose. Much of the total starch produced in the United States during the first half of the nineteenth century was made from potatoes. Late in the last century there were about 150 potato starch factories in Maine, New Hampshire, Vermont, Ohio, Michigan, Wisconsin, and Minnesota. After about 1880, the production of potato starch decreased because of the rise of the cornstarch industry and also because the improvement in transportation made it profitable to grow and move more table stock potatoes to distant markets.

Cornstarch was first produced in 1842 and rapidly became the principal starch since it was soon apparent that potato starch could not compete in price. Potato starch then became a specialty starch and retained this position regardless of its higher price. Aroostook County, Maine, became the center of the potato starch industry, the starch factories forming an outlet for cull and surplus potatoes. About 20 factories now operate in Maine, with a total capacity of approximately 50 million pounds a year. Four starch factories established in Idaho in 1941 can produce about 30 million pounds of starch annually. More recently still, a cooperative established a potato starch factory in Lynden, Washington, where the starch is converted to glucose. If all the starch factories in the country operated at capacity for a 200-day season, 10 to 15 million bushels (2½ to 4 per cent of the total production) of potatoes would be consumed. Table 2 shows the amounts of potatoes consumed in starch manufacture and the quantities of starch produced annually from 1930 to 1945.

The daily capacity of existing starch plants ranges from 5 to approximately 25 tons. A starch factory which produces 5 tons of starch per day for a 200-day operating season needs approximately 300,000 bushels of potatoes. It should preferably be located in a region where potatoes can be stored and where an abundant supply of good water is available. Because the raw material cannot be kept in ordinary stor-

TABLE 2 *Quantities of potatoes used and potato starch produced in the United States from 1930 to 1945**

Crop	Potatoes Used for Starch Manufacture 1000 Bushels	Computed Quantity of Starch Produced (1000 pounds) (On basis of 7.27 Pounds Starch per Bushel)
1930	1,662	12,088
1931	2,554	18,574
1932	1,343	9,768
1933	1,399	10,174
1934	5,319	38,684
1935	1,475	10,728
1936	1,834	13,338
1937	3,680	26,764
1938	2,932	21,324
1939	2,699	19,630
1940	8,030	58,400
1941	4,892	35,578
1942	3,308	24,078
1943	10,050	72,112
1944	4,005	29,124
1945	5,682	41,320

*Source: Potato Division, Fruit and Vegetable Branch, Production and Marketing Administration, United States Department of Agriculture, Washington, D. C.

age during the summer, potato starch factories seldom operate more than 8 months of the year, from about 1st of October to the 1st of June. In addition to the short operating season and uncertain supply of raw material, the problem of disposing of starch-factory wastes, which has become increasingly important in recent years because of the movement to eliminate stream pollution, has been a drawback. The fact that potatoes for industrial processing cannot be economically transported great distances has favored the plan of locating small factories throughout a high production area, for example, Aroostook County, Maine, instead of the establishment of a few, centrally located, larger plants.

The Green Mountain variety of potato formerly constituted a high percentage of the total supply grown, but in recent years there has been a trend in Maine toward the production of Katahdin, Sebago, Chippewa, and other varieties which contain less starch but are more disease-resistant. This switch to potatoes of lower starch content has discouraged expansion of the potato starch industry in Maine.

In processing potatoes for starch recovery, the methods in general consist of grinding the washed tubers to a pulp, screening the fibrous material from an aqueous starch suspension, removing impurities from

the starch, and drying. A starch factory which extracts 85 per cent of the available starch in potatoes is considered to be relatively efficient. Thus 100 pounds of potatoes containing 13 per cent starch, about the average for the varieties now grown, will yield about 11 pounds of dry starch or approximately 13 pounds of starch containing 17 per cent moisture, the average for commercial potato starch. Potato starch currently brings the factory 8 cents per pound which accounts for a gross return of $1.04 from 100 pounds of potatoes. No reliable manufacturing cost data are available, but total costs are estimated at 1 to 2 cents per pound of starch. It is evident that, after manufacturing costs are taken into consideration, the price which may be paid for the raw material is much less than the selling price of table stock potatoes.

Potato starch is used principally in the textile mills of New England and the southern states for sizing cotton, spun rayon, and worsted warps. It is also used to a less extent as such and in the modified form of dextrin in adhesives, in paper sizing, in the baking industry, in fine laundering, and as a thickening agent for various applications.

Prior to World War II, potato starch was regularly imported from the Netherlands to supplement a deficient supply of high-grade domestic starch. The construction of modern plants in Maine and Idaho in the period 1938-1941 and the improvement in manufacturing operations resulted in a domestic supply of high-quality starch which satisfied the most essential needs during the war and postwar period. The potato starch industry appears to be firmly established, and a modest expansion could probably take place without saturating the market.

Food Processing.—The *per capita* consumption of potatoes has markedly declined during the past 35 years or so (from 197 pounds in 1910 to 126 pounds in 1946). This trend has been attributed to various factors, such as (a) increasing competition of other vegetables, both fresh and frozen, which are available throughout the year in attractive forms; (b) gradual rise in the economic level of the average American, with the accompanying ability to purchase a greater variety of the more expensive vegetables; and (c) the erroneous conception that potatoes are more fattening than other carbohydrate foods. The decreased consumption of potatoes might be due also to the fact that the population shift from rural districts to urban centers has resulted in a demand for foods which involve less preparation than is entailed in peeling and cooking potatoes. The consumption, therefore, might rise if potatoes were processed into forms which are either ready to eat or readily prepared for the table. In any event, in recent years there has been an increase in the amount of potatoes going into pro-

cessed foods, and this trend may in part offset the lower consumption of potatoes in the ordinary form.

Among food products made from potatoes, chips occupy a prominent place. Potato chips have been produced for many years, but only in the last 10 to 15 years has the industry grown to large proportions. In 1946, 15.4 million bushels of potatoes were processed into 243.6 million pounds of chips, an average yield of 25.8 pounds of chips per 100 pounds of raw potatoes (5). The average *per capita* consumption in 1946 was 1.8 pounds of potato chips. The shortages of vegetable fats and processing machinery during the war retarded expansion of the potato-chip industry, but with the current improvement in these supplies further expansion is anticipated.

In producing chips, clean, peeled, potatoes are sliced thin, washed and drained to remove loose starch granules, and then fried in oil. Certain varieties of potatoes are better for making chips than others, but an important factor, regardless of variety, is the so-called reducing sugar content of the potatoes (3). Chips produced from potatoes containing an appreciable amount of reducing sugars are dark and relatively unpalatable. Freshly dug potatoes are generally low in sugar content, but they accumulate sugars in cold storage. If such potatoes are kept at approximately 60° to 70° F. for several weeks, however, the sugar content is reduced. Inasmuch as chips sell for a good price and potatoes of a certain type must be used, potatoes intended for chips bring a premium above that of ordinary table stock.

Potato flour seems to have been the first processed potato product to reach quantity production. It was produced in the United States during the first World War as a substitute for wheat flour. In producing flour, the potatoes are peeled, generally cooked, dried, and then ground to a powder or meal. Potato flour is used in admixture with wheat flour in the baking industry, as a "breading" agent for meats, poultry, and vegetables, as a thickening agent in soups and sauces, and as an extender in sausages, meat loaf and scrambled eggs. About 20 million pounds of the flour are produced annually, requiring about 1¾ million bushels of potatoes. Most of the potato flour is produced in four factories in Idaho. Other plants are located in Michigan and Minnesota. Although potato flour is evidently well established in its limited market, the growth of the industry has been rather slow.

A recent development in the merchandising of potato flour consists of a blend of the flour with dehydrated onions and seasoning to comprise a potato pancake mixture.

In addition to potato chips and flour the food processing industry also produces dehydrated potatoes, canned potatoes, potato soup, and

potato salad, fast-frozen preparations, and peeled fresh potatoes. During World War II, a considerable tonnage of potatoes was dehydrated, chiefly for shipment to the armed forces. The potatoes were diced, riced, shredded, or granulated and then dehydrated in either the cooked or blanched, uncooked form. At the end of the war, most of the manufacturers stopped their operations, but a few have continued in the field and now turn out a dehydrated product which, after proper reconstitution, is difficult to distinguish from freshly cooked mashed potatoes.

Potatoes have been canned to some extent in the last few years. Generally, whole, peeled potatoes of small size are used for this purpose. French-fried, sliced, diced, and julienne potatoes, potato salad, and potato soup are also canned.

Frozen French-fried potatoes have been placed on the market recently. It is also reported that raw sliced potatoes are being fast frozen.

Potato-peeling plants have been established in several large Eastern cities. This industry delivers peeled ready-to-cook potatoes to restaurants, hotels, and other large consumers.

Livestock Feeding. For many years, cull potatoes have been fed to livestock on the farms where the potatoes were grown. This is probably the most economical utilization of cull potatoes, since no transportation or processing is required. As a rule, the potatoes are cooked if they are to be fed to hogs, but raw potatoes, usually chopped or ground, are fed to sheep, dairy cattle, and horses. Perhaps 5 per cent of the annual crop of potatoes is disposed of in this way.

If it is not practicable to store cull and surplus potatoes or use them immediately in the fresh form as feed, perhaps the next most feasible thing is to convert them into silage. In the form of silage, potatoes may be stored for at least one year. Potato silage has about the same palatability as corn silage, and it is approximately equal to corn silage in feed value on the dry weight basis. A number of methods have been followed (6). The potatoes may be either raw or cooked. They may also be mixed with grass, clover hay, alfalfa, or ground corn before being ensiled. The ensiling process may be conducted either in a tower or a trench silo. The trench silo method is apparently the most economical for large-scale operations. Potatoes are loaded into trucks, covered, steamed while on the trucks, and then transported to previously prepared trenches. After a trench has been filled, it is covered with soil or agricultural wastes, such as pea vines. During the summer of 1946, following small-scale experiments in

North Carolina (4) and Colorado (1) which demonstrated the feasibility of the method, about 300,000 bushels of potatoes were ensiled in northern California (2) by this process.

Dehydrated potatoes have been fed successfully to livestock. This material is comparable, if not quite equal, to corn in feed value. In several of the western states during hot, dry seasons, potatoes have been sliced or crushed and subsequently dried in the open air. Perhaps one of the more economical methods for drying potatoes is that practiced in 1946 on the concrete runways of airfields in the desert region of California. Potatoes were crushed with large mechanical equipment and left to dry in the hot, dry air. An alternative procedure of sun drying practiced in 1946 in Kern County, California, was to spread whole potatoes on a bed of straw and let them dry for three months. Another economical method of air-drying was used in North Dakota during the winter and spring of 1946-1947. Whole potatoes were spread on the ground to freeze and subsequently dehydrate. If it is not practicable to use air-drying because of climatic conditions, as much water as possible can be removed by pressing and then the press cake can be thermally dried. A plant was established in Grand Forks, North Dakota, recently to mechanically dewater and thermally dry cull potatoes for feed. During periods of potato surplus and grain shortage, potatoes have been dehydrated in cider mills and sugar beet plants for production of feedstuff and raw material for alcoholic fermentation. Experience has shown, however, that the mechanical and thermal dehydration of potatoes for production of feed and fermentation raw material is uneconomical unless the potatoes are obtained at a low cost and the product is sold at a relatively high price. By special arrangement with the United States Department of Agriculture, one plant is now dehydrating potatoes at the rate of 60 carloads (900 tons) per week. If conditions continue to be favorable for these operations, the cost of this plant may be amortized in one or two seasons.

It has been estimated by the Chemical Engineering and Development Division of this Laboratory that the cost of drying potatoes by an economical method which also reduces explosive hazards to a minimum is about $23.00 a ton of product containing 12 per cent moisture. In their improved process the potatoes are hammer-milled, mixed with dried product to reduce the moisture content to 40-45 per cent, and dried in a rotary steam-tube drier. The estimate for this process includes all costs except that of the potatoes and the selling cost of the product. If it is assumed that dehydrated potatoes have 0.9 the feed

value of corn and that corn is worth $1.00 a bushel, then, in order to compete, raw potatoes would have to be delivered at the dehydration plant at about $1.40 per ton, if the processor is allowed a return of 10 per cent on his investment. With corn at $2.00 a bushel, potatoes would be worth about $8.70 a ton. In several industrial applications, for example livestock feeding, starch production, alcoholic and certain other fermentations, and glucose sirup and dextrose sugar production, potatoes must compete with corn. Table 3 shows that dehydrated potatoes compare closely with corn in composition, with the exception that corn contains much more fat.

TABLE 3 *Typical analyses of potatoes and corn*

	Potatoes	Dehydrated Potatoes*	Corn
Moisture, per cent	78.9	10.0	10.8
Carbohydrate (mainly starch), (Per cent)	17.4	74.4	73.4
Protein, per cent	2.1	9.0	10.0
Fat, per cent	0.1	0.4	4.3

*Values obtained by assuming dehydrated potatoes contain 10 per cent moisture and computed from analysis of fresh potato without regard to the loss of protein during processing.

Corn dries out naturally on the cob to about 10 per cent moisture content, whereas potatoes must be transported to a processing plant and dehydrated at considerable expense to reduce the moisture content to a comparable percentage.

Alcohol Production. In Germany and in certain other European countries, potatoes have been used for many years as raw material for alcoholic fermentation. Varieties of potatoes having high-starch content were grown for this purpose, and the industry was controlled by the government and closely integrated with the potato industry.

A pilot plant for the conversion of cull potatoes into alcohol was established by the state of Idaho at Idaho Falls about ten years ago. After several years of operation, the plant was sold to a private company, which continued to operate for a while. Somewhat larger distilleries (with a capacity of about 5000 gallons of 190-proof alcohol per day each) were established at Newmarket, New Hampshire, in 1944 and at Caribou, Maine, in 1946 for the production of alcohol from potatoes. In this process, the potatoes are washed, cooked, and then cooled to the temperature at which malt converts the starch to sugar. The sugars are fermented to alcohol by yeast, and finally the alcohol is distilled from the mash.

One hundred pounds of potatoes will produce about one gallon of 190-proof alcohol. If industrial alcohol is produced, the distiller

must obtain potatoes at a relatively low price in order to operate profitably. If the distillery produces alcoholic beverages, a greater financial return is realized from the alcohol. The future for potato alcohol in this country seems to depend largely on whether potato liquors of unique flavor can be popularized. Since the Federal tax represents the main part of the cost of alcoholic beverages, the higher cost of potatoes as a raw material would be relatively unimportant. Consumer acceptance of blended whiskey containing potato alcohol, however, has not been particularly encouraging.

In addition to the three distilleries established specifically for fermentation of potatoes, many larger distilleries used dehydrated potatoes during 1943 and both fresh and dehydrated potatoes in 1946. While grain was scarce, distilleries were glad to receive potatoes as raw material, which was made available to them principally through the diversion program. With grain again available, however, there has been a tendency to return to corn. Several distilleries object to the use of potatoes on account of the higher material cost and the higher handling expense caused by the bulkiness of potatoes. However, potatoes may again be widely used for fermentation if corn prices remain unusually high and potato surpluses occur. A large proportion of the potato alcohol produced in 1947 has gone into industrial uses, little now being used for beverage purposes. Some potatoes recently have been fermented to butyl alcohol instead of ethyl alcohol.

Glucose Sirup and Dextrose Sugar. In Germany, The Netherlands, and certain other European countries where potatoes are the common source of starch, the production of potato sirup and dextrose sugar is a long-established industry. During World War II, supplies of cane and beet sugars in the United States became entirely inadequate. Sales of corn sugar increased from 459 million pounds in 1939 to 771 million pounds in 1942 (7). Sales of corn sirup increased from 1,142,000,000 pounds to 2,025,000,000 pounds, or 77.3 per cent during the same period (7). Even at this high rate of production, the available supply was far short of the demand, and sources of starch other than corn were sought to supplement the deficient supply of cornstarch for sirup.

In 1942, a plant was established at Lynden, Washington, by the Northwest Chemurgy Cooperative to produce sirup from potato starch. The process used by this organization in producing potato sirup has not been made public. In converting starch to sirup hydrochloric or sulfuric acid in low concentration is ordinarily used as catalyst, the reaction being carried out in about 10 to 15 minutes in an autoclave.

The resulting liquor, containing dextrins, maltose, and dextrose, is then neutralized, filtered, decolorized, and evaporated to sirup under reduced pressure.

Corn sirup generally sells for a fraction of a cent above the cost of the starch and at less than the cost of potato starch. It appears that in the absence of quality advantages potato sirup will have some difficulty in competing with corn sirup under normal conditions.

A few sugar beet factories which dehydrated surplus potatoes in recent years, during the off-season in the beet industry, converted by-product starch into sirup, but the considerable outlay of additional equipment required for outfitting a sugar beet factory to produce glucose sirup has discouraged further development along this line.

Disposition of Recent Potato Crops

The total potato production in 1946 was 475 million bushels, about 100 million bushels in excess of our normal requirements. Table 4 shows the disposition of this surplus.

Table 4 *Disposition of surplus potatoes from the 1946 crop. Stocks removed from the market by the government and diverted into various outlets.**

Outlet	Million Bushels
Alcohol production	29.2
Unharvested; deteriorated; lost in field storage	26.5
Livestock feed	18.3
Exported	11.3
Starch (mainly), flour, glucose	9.5
School lunches; direct relief to public institutions	3.2
Disposition undetermined (pending receipt of final reports)	0.5
Total	98.5

*Supplied through the courtesy of A. E. Mercker, Acting Chief, Potato Division, Fruit and Vegetable Branch, Production and Marketing Administration, United States Department of Agriculture, Washington, D. C.

Table 4 does not include figures on most of the potatoes processed in Idaho for starch, alcohol, feed, and other purposes; these were mainly culls purchased by processors directly from growers and shippers. In addition, an estimated five million bushels of potatoes were purchased outside of the Government program by distillers during the spring and summer of 1946.

Considerable criticism has been caused by failure to export more

surplus potatoes during the world food shortage. The greater weight and bulk of potatoes, as compared with grain of equivalent food value, and their perishability have discouraged exportation of fresh potatoes on a larger scale. On the other hand, foreign relief agencies have in general refrained from contracting for dehydrated potatoes because of their high cost.

Present Investigations

Investigations on potatoes are in progress at the Eastern Regional Research Laboratory along the following lines: (a) Conversion of potatoes into stable forms, for example, a dehydrated form or a concentrated hydrolyzate, which may be stored. Estimates based on batch operations at atmospheric pressure indicate that it will cost about $38.80 per ton of dry solids to prepare feed-grade potato "molasses" (acid-converted, neutralized, and concentrated), as compared with $26.20 per ton of dry solids for dehydrated potatoes. It is not known what the cost would be with a continuous process at higher temperature and pressure. (b) Improvement of the economic position of potato starch by technological advances in processing and by extension of uses, thereby encouraging greater diversion of potatoes into the starch industry. Studies of the fundamental physical properties of potato starch are being made which it is hoped will suggest new applications in which potato starch is superior to others. (c) Development of new industrial processes that will utilize the potato, for example, fermentation of saccharified potatoes to lactic acid, and possibly butylene glycol, acetone, and butanol. In such processes the mineral and protein contents of the potato might give it an advantage over some other carbohydrate bases, such as, corn starch, to which fermentation nutrients must be added. (d) Improved methods for storing fresh potatoes for later use as food or industrial raw material.

The general objective of the research in the National Potato Breeding Program, carried out by the Bureau of Plant Industry, Soils, and Agricultural Engineering in cooperation with about 25 State Agricultural Experiment Stations, is to develop new potato varieties that will combine as many of several desirable characteristics as possible, including high yield, disease resistance, good edible quality, and pleasing appearance of skin and flesh. Earlier experiments by the Department on imported varieties of European potatoes of high starch content were disappointing in that yields were poor and edible quality inferior. Further work in this field may eventually develop a potato variety of high starch content which will not only be better for table

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7. United States Department of Agriculture, Agricultural Statistics 1946, Table 54, page 47.

use but also provide a more economical raw material for industrial utilization.

Outlook for Utilization of Potato Surpluses

In all probability no single industrial use will solve the problem of potato surpluses. Instead potatoes may continue to be used in several processes but more efficiently than in the past. There is the possibility, however, that an industrial process will be found in which the minor constitutents of the potato will give it some advantage over corn, wheat, and other high starch crops. If potatoes are expected to compete with corn on an equivalent starch basis, however, the potato industry and scientific workers must unite to make industrial processing of potatoes more profitable. The potato program under the Research and Marketing Act of 1946 may be expected to aid in solving problems of production, marketing, consumption, and utilization.

Closer grading of potatoes and state marketing agreements may result in better potatoes for the table stock market, an increase in consumption, and the reward of a higher selling price. Closer grading to improve quality will also produce a larger supply of culls for industrial use. It seems then that the potato industry might be able to enter operations in the processing field, with a higher price from better quality table stock potatoes helping to offset unfavorable economics. If no good use is made of the substandard potatoes, the alternative is dumping, which entails expense, is hazardous from the standpoint of spreading potato diseases, and is abhorrent to the American public, particularly because of starvation conditions in many parts of the world.

The widespread adoption of improved methods of storing potatoes to make them suitable for utilization over a longer period of time should be helpful in dealing with the surplus potato problem. More general practice of ensiling and air-drying potatoes will provide a way of preserving them for later use as feed without expensive processing. Establishment of potato starch and alcohol factories in regions of high potato production should be encouraged in order to provide outlets for the inevitable supply of cull potatoes and for the occasional surplus crops. In addition, the research now in progress on improved varieties, superior processing methods, and new outlets and applications should improve the position of the potato as an industrial raw material.

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